Control Architectures for Distributed Control of Mobile Robots

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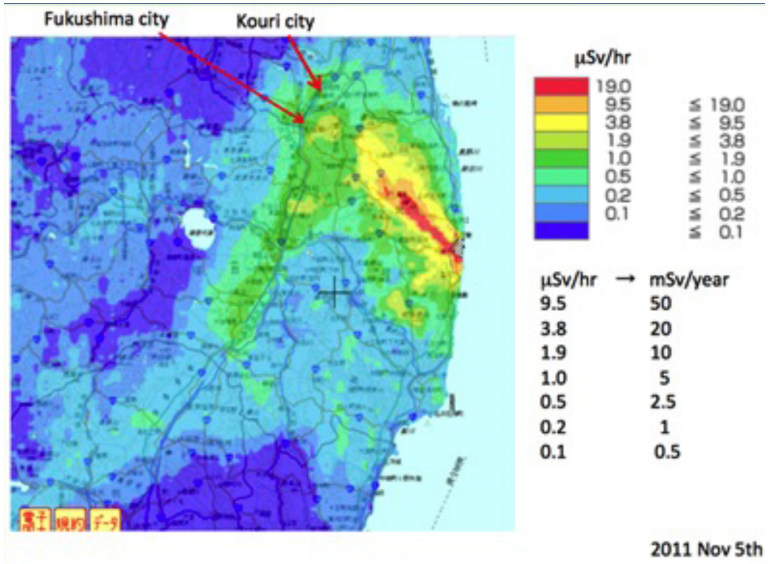
Motivating Scenarios

Fukushima Disaster (2011)



Deep Water Horizon (2010)

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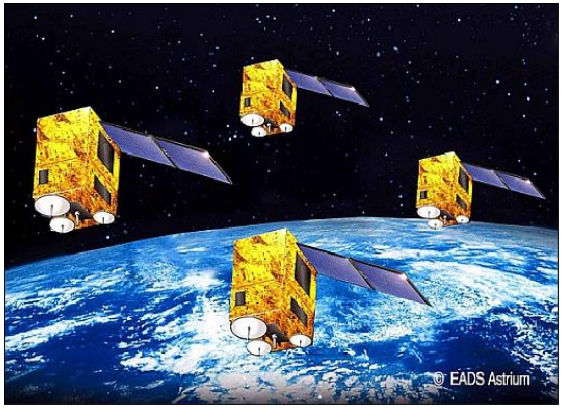
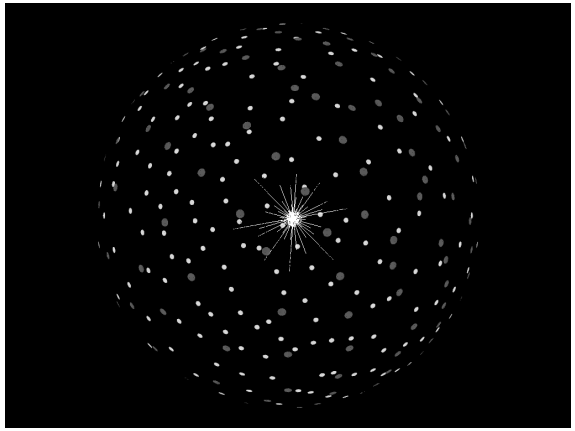


EADS Astrium



Dyson Swarm (Why not !)

- Have figures for: Formation forming, flocking, source-seeking,

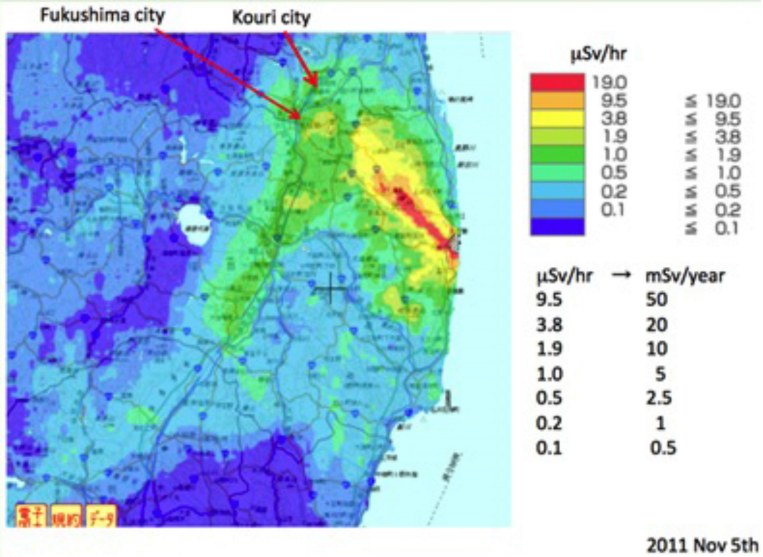
Physical Agent Dynamics

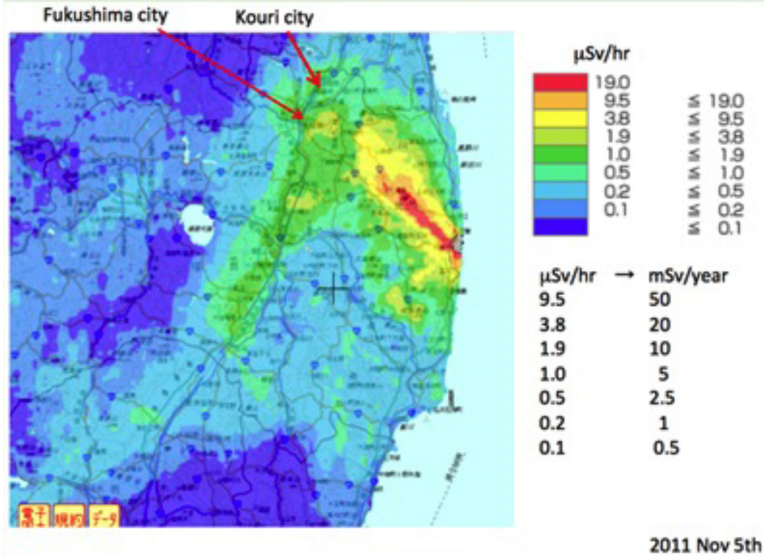
- Crazyflie picture
- Hippo campus picture
- Zooids picture
- LTI/LPV agents, non-holonomic constraints

Core Idea

- Control of a single non-linear (possibly non-holonomic) agent: Well-studied problem and various techniques available
  - LPV
  - Dynamic-inversion
  - Flatness-based control
- About three decades of work on studying interconnections of "simple" agent dynamics where simple could for example be
  - single/ double integrators
  - positive systems
- Can we maintain this separation in the controller design? i.e design local agent controllers and study the interconnections of these closed loop systems
- Can we give some stability and performance guarantees with such a strategy?
- What kind of control architectures are possible?

Different Control Architectures





Coupled architecture

- Maintenance of relative positions important (e.g asdf)
- inter-agent distances are low
- High disturbances
- Combination of the two

Coupled architecture

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Coupled architecture: Consensus/ Formation control

- Block diagram
- Some related work
  - Consensus(Formation) with a fixed Laplacian [Fax and Murray,??] -> Modal decomposition
  - Consensus(Formation) with a uncertain Laplacian [Popov, eichler, Hoffman,??] -> Modal decomposition
  - Flocking with a fixed Laplacian [Francis]
  - Interconnections of dissipative systems -> Mark Spong

Coupled architecture: Flocking

- Flocking of double integraor agents [1]
- Flocking of robotic agents [2]
- Open problem

[1] Rantzer,2011
[2] Olfati Saber,2011

Coupled architecture: Flocking and source-seeking

- Block diagram with double integrators
- Analysis result including the external field
- Experimental results

Coupled architecture: Flocking and source-seeking with non-linear agents

- Block diagram with double integrators and non-linear agent
- Analysis result including the external field
- Simulation results

Coupled architecture: Some speculative ideas and open questions

- Use IQCs to obtain exponential convergence rates of local closed loops and use singular perturbation argument such as in [Mesbahi]

Decoupled architecture: Consensus/ Formation control

- Block diagram
- Some related work
  - Wei Ren [Module diagram]
  - Fax and Murray discrete-time analysis []
  - Egerstedt and Cortes []: Wrapping local controllers

Decoupled architecture: Formation forming

- Hespe
- Submitted ACC
- Crazyflie experiments

Decoupled architecture: Non-ideal networks

- MJLS information flow dynamics
- r2 or w2 measures (Daniel will talk more about this)
- IQC analysis of consensus [rantzer] -> Scalable condition
  - Need a stochastic version of the result in [Rantzer]

Conclusions

- ASDF

Thank you